TIMING, EXTENT AND CHARACTER OF LATE, CAINOZOIC FAULTING ON THE EASTERN MARGIN OF THE MT LOFTY RANGES, SOUTH AUSTRALIA.

by R. P. BOURMAN* & J. M. LINDSAY†

Summary

BOURMAN, R. P. & LINDSAY, J. M. (1989) Timing, extent and character of late Cainozoic faulting on the eastern margin of the Mt Lofty Ranges, South Australia. *Trans. R. Soc. S. Aust.* **113**( ), 63–67, 31 May, 1989.

Stream erosion on the eastern flank of the Mt Lofty Ranges has exposed a reverse fault near Cambrai on the Milendella escarpment, indicating a compressive component to the uplift of the ranges. Cambrian rocks have been thrust over Pleistocene fanglomerates and Miocene limestone has been dragged up along the fault zone to an elevation of 160 m asl. This fault may indicate the reactivation of a compressive Palaeozoic fault during the Cainozoic. Diagnostic foraminifera have been identified in samples of the limestone, which is of the Early Miocene Mannum Formation (about 20 Ma), adding support to the unpublished view that the position of the limestone on the escarpment is due to tectonic uplift of 60–90 m since the Miocene.

KEY WORDS: Tertiary limestone, foraminifera, reverse faulting, Mt Lofty Ranges, South Australia.

Introduction

The fault origin of the Mt Lofty Ranges has long been discussed (Benson 1911; Fenner 1930; Sprigg 1945) and the majority of these workers considered that the faults were normal types. Glaessner (1953) presented a model for the tectonic evolution of the Mt Lofty Ranges, which involved basement complex flexuring, that resulted in reverse faulting on the margins of the ranges and normal faulting within them. Campana (1955) preferred to explain the origin of the Mt Lofty Ranges by compressional doming, which led to minor fault disruption on their margins. Gibson (1963)[1] noted that the Clarendon-Ochre Cove Fault displays a reverse habit where intersected by tunnelling operations during the construction of the Clarendon-Happy Valley pipeline. Recently Wellman & Greenhalgh (1988) favoured the view that compressive forces have been important in the formation of the Mt Lofty Ranges. A re-evaluation of exposed fault contacts is required to resolve the nature of the faulting responsible for the uplift of the Mt Lofty Ranges.

The Milendella Fault

There is clear evidence of reverse faulting on the eastern escarpment of the Mt Lofty Ranges as first reported by Mills (1965)[2], and it may indicate the re-activation of Palaeozoic thrust faults. Stream exposures of the Milendella Fault occur west of Cambrai on the escarpment (Angaston MR 390/630) at 160 m asl (Fig. 1). The fault here is of reverse type with brecciated Cambrian schists of the Kanmantoo Group of metasedimentary rocks thrust over Pleistocene fanglomerates. Two pods of Tertiary limestone have been dragged up at a high angle in the fault zone, which dips to the west at 45° (Fig. 2). The Pleistocene fanglomerates affected by the faulting are similar to Pleistocene fanglomerates tilted into a vertical position by movement along the Willunga Fault as Sellicks Beach (May & Bourman 1984). The sediments at Sellicks Beach were related to the Ochre Cove Formation, which May & Bourman (1984) regarded as of Middle Pleistocene age. If the two deposits are correlatives then faulting on the Milendella Scarp probably occurred until the late Middle Pleistocene or the early Late Pleistocene. No unequivocal evidence of dislocation of Late Pleistocene sediments in the area was noted.

It is suggested that during faulting, the Pleistocene fanglomerates were folded, and brecciated basement rocks broke from the hanging wall to tumble on top of the fanglomerates. Calcrete mantles the convoluted fanglomerates, dying out at the fault zone, so that the calcrete may have derived from solution and reprecipitation of the Tertiary limestones dragged to the surface along the fault zone and draped over the top of the fanglomerates. Calcareous pisoliths in this calcrete are typically laminated around cores of locally derived bedrock. This supports the interpretation of *in situ* pisolith formation from the redistribution of Tertiary limestone. Alternatively, if the calcrete has stratigraphic significance (e.g. the upper Middle Pleistocene Bakara calcrete of Firman 1967) then

[1] Gibson, A. A. (1963) Final geological report on the Happy Valley Tunnels Project. S. Aust. Dept of Mines report 57/92 (unpubl.)

[2] Mills, K. J. (1965) "The structural petrology of the Milendella area of South Australia". Ph.D. Thesis, University of Adelaide (unpubl.)

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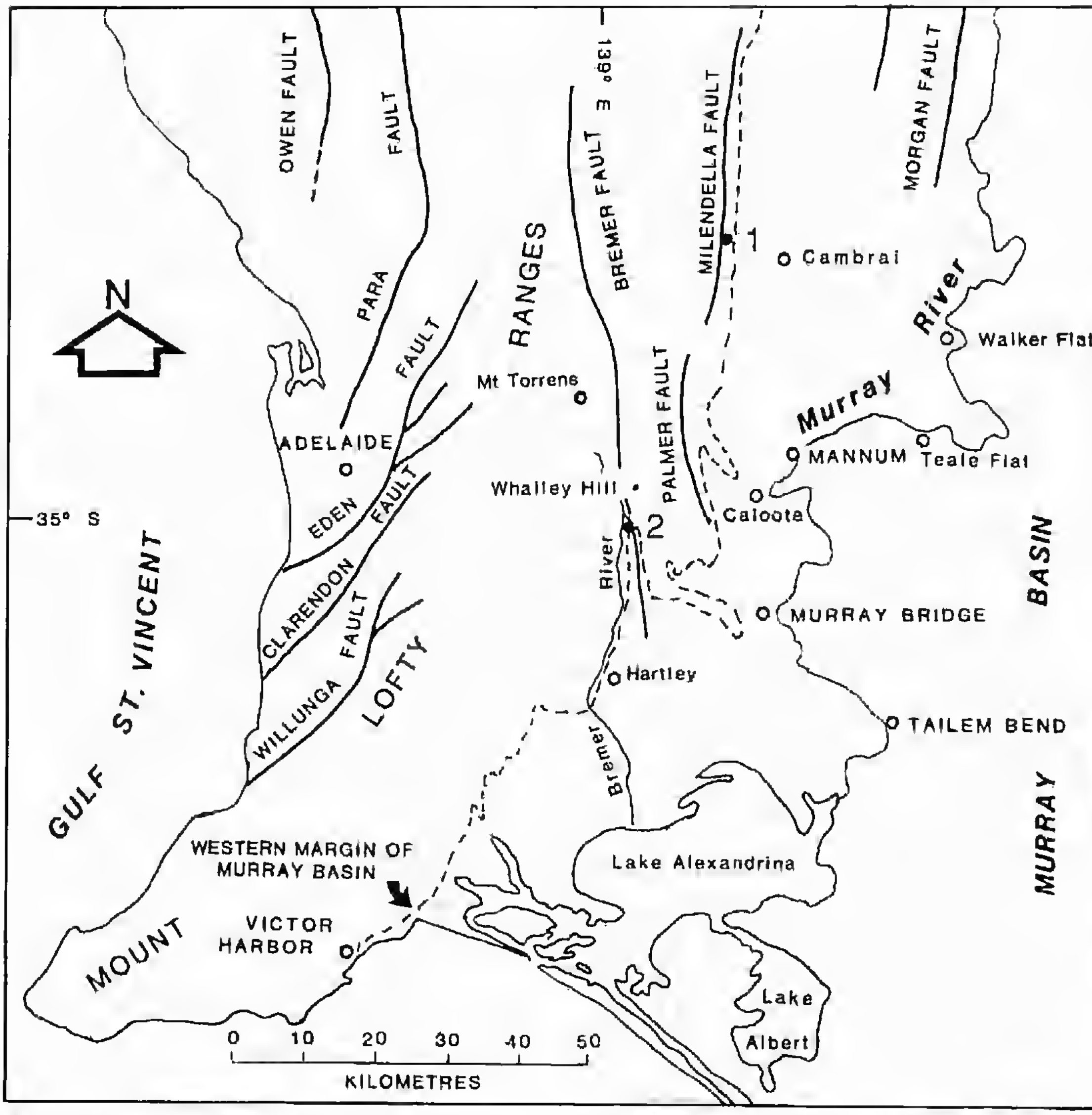

Fig. 1 Location map showing major fault zones; [1] site of fault exposure near Cambrai and [2] *Lepidocyclina*-bearing limestone in the Bremer valley.

the relationships may indicate fault disruption of the calcrete in the Late Pleistocene. It is not possible to determine the amount of offset accomplished during this postulated Pleistocene phase of faulting without detailed drilling. However, Mills (1965)[2] shows a thickness of some 30 m of Pleistocene sediments in section at the scarp (Fig. 3), and as the limestone must have been dragged up from below this level, this suggests an offset of less than 30 m. Dislocation of Early Pleistocene marine sediments across the Willunga Fault was reported by May & Bourman (1984) illustrating similar post-Early Pleistocene faulting of about 40 m on the opposite side of the ranges. It is interesting to note that although there is clear evidence of geologically recent faulting on the eastern margin of the Mt Lofty Ranges, there is no pronounced fault scarp associated with it, which may suggest that the scarp formed largely in brecciated rock and rapidly degraded.

Mills (1965)[2] suggested that displacement on the Milendella Fault since "pre-Tertiary peneplanation" was approximately 335–366 m, and he attributed 250 m of this to the Early Tertiary to Miocene, and 60–90 m to post-Miocene faulting. He noted Miocene sediments (?Morgan Limestone) at elevations up to 160 m on the scarp, correlated them with Miocene strata under the Murray Surface and

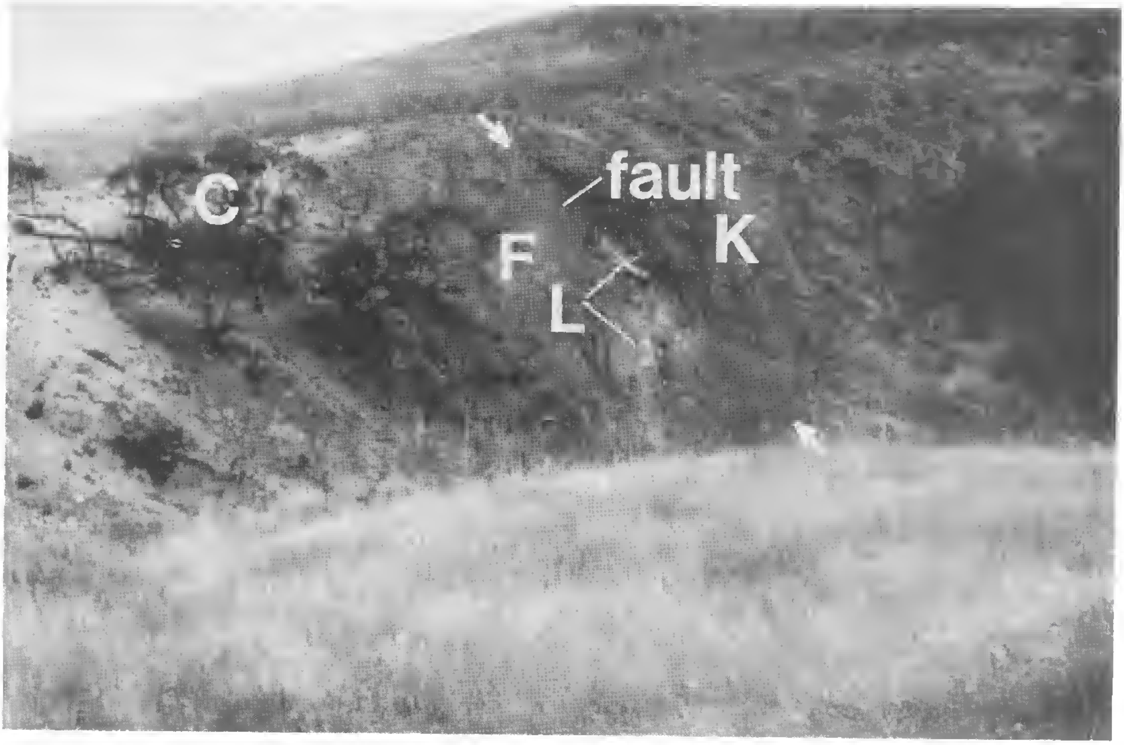

Fig. 2. Fault exposure near Cambrai. View south along the eastern escarpment of the Mt Lofty Ranges. Cambrian schists (K) of the Kanmantoo Group of metasedimentary rocks have been thrust over (?) Middle Pleistocene fanglomerates (F). Light coloured calcrete (C) mantles the fanglomerates and two pods of Miocene limestone (L) occur in the fault zone (arrowed), which dips to the west at approximately 45°.

attributed the difference in elevation to tectonic dislocation. Twidale & Bourne (1975) did not deny recent fault activity but preferred to interpret the perched limestone as essentially due to Tertiary eustatic influences, with the limestone under the Murray Basin being the older, lower Mannum Formation and that on the scarp as the younger and higher Morgan Limestone. Thus they discounted the view that there had been 60–90 m of dislocation on the Milendella Fault since the Miocene and argued for an erosional origin for the lower part of the scarp. The resolution of this conflict may be achieved only by an accurate age determination of the Miocene limestones on the Milendella scarp to compare with those from the Murray Basin. Palaeontological work reported here demonstrates that the limestone on the scarp, at least in this locality, is from the lower part of the Mannum Formation.

Age and facies of the Tertiary limestone in the fault zone

Four samples have been examined from the two pods of Tertiary limestone dragged up in the fault zone.

Portions were crushed gently in a pestle and mortar to disaggregate partially, boiled in a dilute solution of sodium bicarbonate with a drop of detergent, washed free of mud through a very fine sieve, dried, and picked for foraminifera under a binocular microscope. Slides with the foraminiferal microfaunas are stored in the Biostratigraphy Branch collections of the S. Aust. Department of Mines and Energy.

Lithology

All four samples comprise quartzose fossiliferous sandy limestone (biogenic calcarenite). The rocks are cream to brown, hard to friable, somewhat recrystallised and, in part, leached. Quartz and minor lithic sand content is considerable and poorly sorted, ranging from very fine grained to very coarse grained. Quartz and lithic grains up to 10 mm are present. There are occasional pale green glauconite infillings, somewhat oxidised.

Barnacle plates are frequent and notable; echinoid, molluscan and bryozoal fragments are frequent to common; foraminifera are common but mostly recrystallised; ostracods, *Ditrupa* tubes, fish and decapod fragments, and algal oncolites are rare.

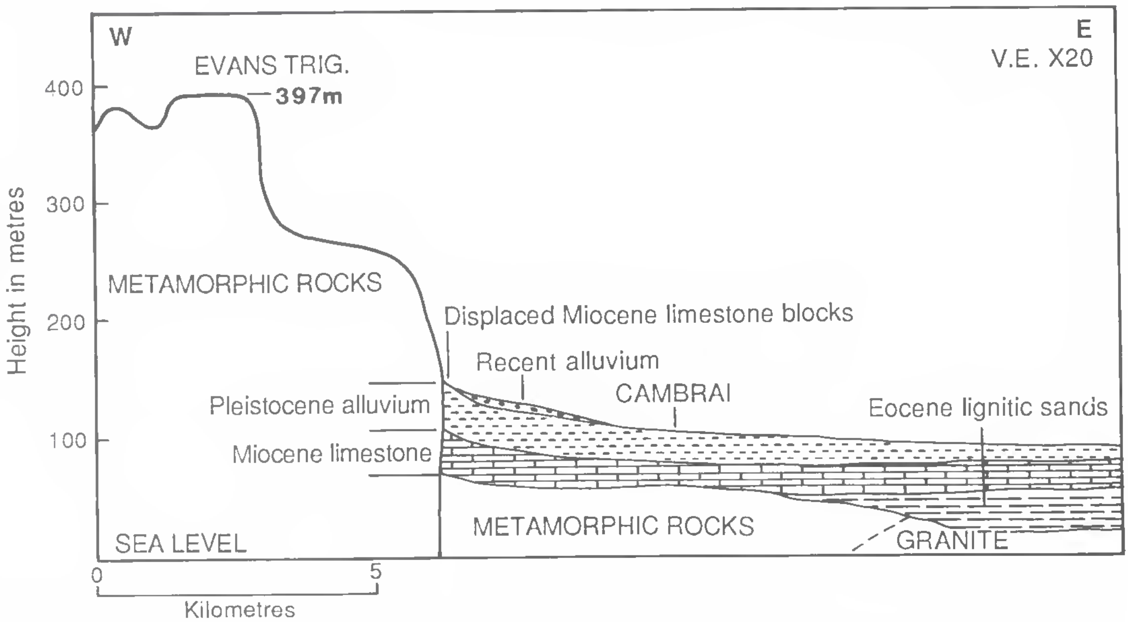

Fig. 3. Cross section through the eastern margin of the Mt Lofty Ranges to the Murray Basin near Cambrai (after Mills 1965[2]).

Discussion of foraminifera, age and correlation

The four samples have much in common and the microfaunas will be considered together (Table 1). Numerically, all the microfaunas are dominated by *Elphidium chapmani* and *Notorotalia* cf. *miocenica*, but these are not the most biostratigraphically significant.

The overlap of the top of the range of *Sherbornina atkinsoni* and the bottom of the range of *Operculina victoriensis* in S. Aust. indicates an early Longfordian, Early Miocene age (Wade 1964; Lindsay 1985). For the Murray Basin proper, Ludbrook (1961) only overlapped these ranges in lower Mannum Formation, and this has been borne out by subsequent experience. Other foraminifera present in the four samples are generally consistent with Longfordian Stage and Early Miocene age. *Notorotalia miocenica* has been scarcely recorded previously from S. Aust., so the slightly earlier age here of a related form, compared with the range in Victoria (Carter 1964) is not regarded as incongruous. The solitary and small planktonic specimen identified as *Globigerina* sp. is non-diagnostic.

TABLE 1. *Foraminifera: Table of occurrences of selected species.*

Foraminifera	Samples			
	F23/83	F24/83	F2/88	F3/88
Discorbis sp. from group *D. balcombensis* Chapman, Parr & Collins -*D. cycloclypeus* Howchin & Parr	R	R	F	F
Ammonia sp.	–	V	–	R
Pararotalia verriculata (Howchin & Parr)	V	V	–	V
Sherbornina atkinsoni Chapman	–	–	–	V
Elphidium chapmani Cushman	C	C	A	A
E. crassatum Cushman	F	R	C	F
E. parri Cushman	–	–	–	V
Notorotalia cf. *miocenica* (Cushman)	F	F	C	A
Operculina victoriensis (Chapman & Parr)	V	R	V	R?
Globigerina sp.	–	–	–	V
Amphistegina sp.	–	–	–	R
Cibicides vortex Dorreen	–	–	V	–
Planolinderina plana (Heron-Allen & Earland)	–	–	V	–

(Abundances: V = very rare; only one or two specimens recovered in thorough picking. R = rare; 3–5. F = frequent; 6–10. C = common; 11–25. A = abundant; more than 25).

The lithology of the samples is consistent with, but not unique to, Mannum Formation as described by Ludbrook (1961) and observed subsequently. This Early Miocene Mannum Formation in the fault zone is distinctly older than the elevated, *Lepidocyclina*-bearing, Morgan limestone reported from the Bremer valley east of Kanmantoo (Lindsay 1986[3]): about 20 Ma compared with 16 Ma (Lindsay 1985).

Environment of deposition

The variety and nature of the fauna indicate marine conditions. Three lines of evidence suggest a shallow-marine, littoral-neritic environment: the notable frequency of barnacle remains, the restricted *Elphidium*-rich foraminiferal facies almost lacking planktonic forms, and the quartzose and lithic clastic component of the limestone, with gravel-sized grains. This corroborates the sedimentological evidence of Mills (1965)[2], who proposed a near-shore environment for the deposition of the limestone.

Conclusion

The evidence presented here demonstrates that most of the elevational difference between the Mannum Formation limestones on the escarpment, near Cambrai, and under the Murray Basin can be attributed to tectonic dislocation in the past 20 Ma as originally suggested by Mills (1965)[2]. Furthermore, it has also been demonstrated that there has been at least 100 m (and probably much more) of tectonic offset of the early Middle Miocene *Lepidocyclina*-bearing Morgan Limestone that occurs in the Bremer Valley (Lindsay 1986)[3] in the past 16 Ma. Consequently, evidence of considerable tectonic dislocation of Tertiary limestones on the eastern side of the Mt Lofty Ranges, separated by 50 km, together with faulted Pleistocene sediments provides strong support for pronounced tectonism since the Middle Miocene. Without denying the evidence for eustatic influences in the Tertiary (e.g. Vail & Hardenbol 1979) it is clear that post Middle Miocene faulting is far more significant in the evolution of the east Mt Lofty Ranges than suggested by Twidale & Bourne (1975). Furthermore, the clear exposure of a reverse fault on the eastern margin of the Mt Lofty Ranges supports the notion of a compressive component to the forces involved in the Tertiary uplift of the eastern Ranges.

[3] Lindsay, J. M. (1986). New record and tectonic implications of a high level *Lepidocyclina*-bearing limestone, Bremer Valley, eastern Mount Lofty Ranges. S.A. Dept of Mines and Energy report 86/66 (unpubl.).

Acknowledgments

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INTERTIDAL COMMUNITIES OF NORTHERN SPENCER GULF, SOUTH AUSTRALIA

*BY R. C. AINSLIE, D. A. JOHNSTON & E. W. OFFLER**

Summary

The fauna of the intertidal mudflats of northern Spencer Gulf was monitored between 1982 and 1986. Two main habitats were identified, the mid intertidal zone, and the seagrass fringing low intertidal zone. These habitats supported quantitatively differing faunas.

There was no evidence of the species impoverishment reported elsewhere for the epizoic fauna of this region. Comparison of the characteristics of the fauna with that of another negative estuary, the Port River in Gulf St Vincent, has provided the basis of a monitoring programme to assess potential environmental stress imposed by power station development in northern Spencer Gulf.

KEY WORDS: Intertidal habitats, benthic fauna, seagrass, Spencer Gulf.